**REMARKS**

Claims 1-20 are rejected under 35 USC §112, second paragraph, as being indefinite. In response thereto, Applicants have amended claims 1 and 11 to address the issues raised by the Examiner. Accordingly, all of the claims are now deemed to be in compliance with 35 USC §112.

Claims 1, 5-7, 10, 11, 15-17, and 20 are rejected under 35 USC §102(a) as being anticipated by Matsuura et al., WO 02/10843 A2.

Claims 1 and 11 have now been amended to recite a deformable membrane structure that can experience strain using a plurality of thin-film actuators that is directly formed on said deformable membrane. The strain is continuous in the strain direction. The deformable membrane provides mechanical support for the microphotonic device while providing high dielectric contrast relative to air underneath said deformable membrane.

Matsuura et al. '843 describes a photonic crystal and a photonic device having a photonic crystal, configured by changing its physical geometry in at least one region to alter light propagation and/or confinement. The configuring means may include electrostrictive, piezoelectric or magnetostrictive components of the photonic crystal, or an actuation device affixed to the photonic crystal.

However, Matsuura et al. '843 describes photonic crystals and supports which have piezoelectric effects. In contrast, the invention has photonic crystals and microphotonic elements that do not exhibit piezoelectric effects, and are furthermore not bonded to the supports that exhibit piezoelectric effects. The deformable membrane structure of the invention comprises a semiconductor material without requiring the need for piezoelectric effects. The requirement is

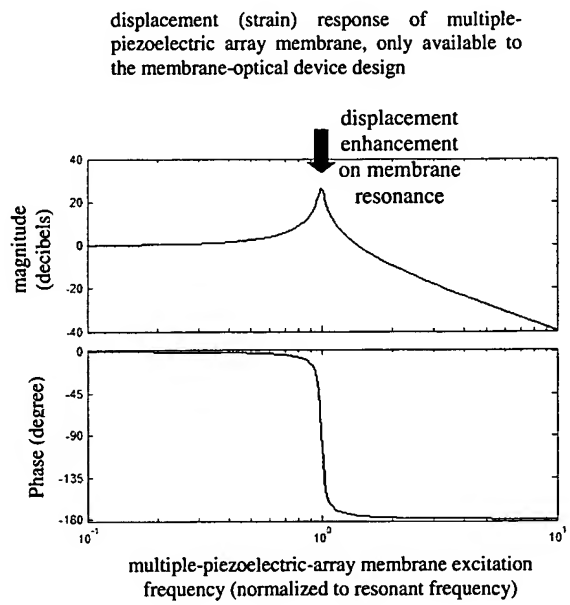
that the piezoelectric materials are attached to the membrane structure, and the flexibility of the membrane. The top portion of the membrane includes multiple microphotonic elements. Furthermore, Matsuura et al. '843 is silent on a waveguide being formed on the deformable membrane. Matsuura et al. '843 describes configuring by changing a photonic crystal's physical geometry in at least one region to alter light propagation and/or confinement, but there is no discussion forming a waveguide on a deformable element for tuning.

Moreover, the invention is based on the plurality of thin-film actuators being formed on the deformable membrane is significantly different to the one discussed in the Matsuura et al. '843 which attaches the optical devices directly onto the piezoelectric materials which is ***DIRECTLY ATTACHED ONTO THE SUBSTRATE***. To illustrate the case, the claimed deformable membrane permits the following three capabilities which CANNOT BE DONE in Matsuura et al. (and hence not mentioned at all):

1. **RESONANT EXCITATION** of the deformable membrane to achieve significantly (100 – 1000 times, depending on the quality factor of the mechanically-resonant membrane) larger displacement (strain) of the strained optical elements.

   This is shown in the below plot for the second-order system of the deformable membrane. In the claimed piezoelectric-array membrane invention – and only in the inventive piezoelectric-array membrane design – the displacement and strain magnitude can be 100 times (20 dB) *or more* when excited (AC) on resonance with the resonant frequency of the membrane, in comparison to just static (DC) voltages applied to fixed piezoelectric substrates (as in Matsuura). The below plot just shows an example of the 100 times (20 dB) calculated

enhancement. Resonant excitation is when the plurality of thin-film piezoelectric actuators has an alternating current (AC) electrical input frequency that matches the mechanical resonant frequency of the membrane.



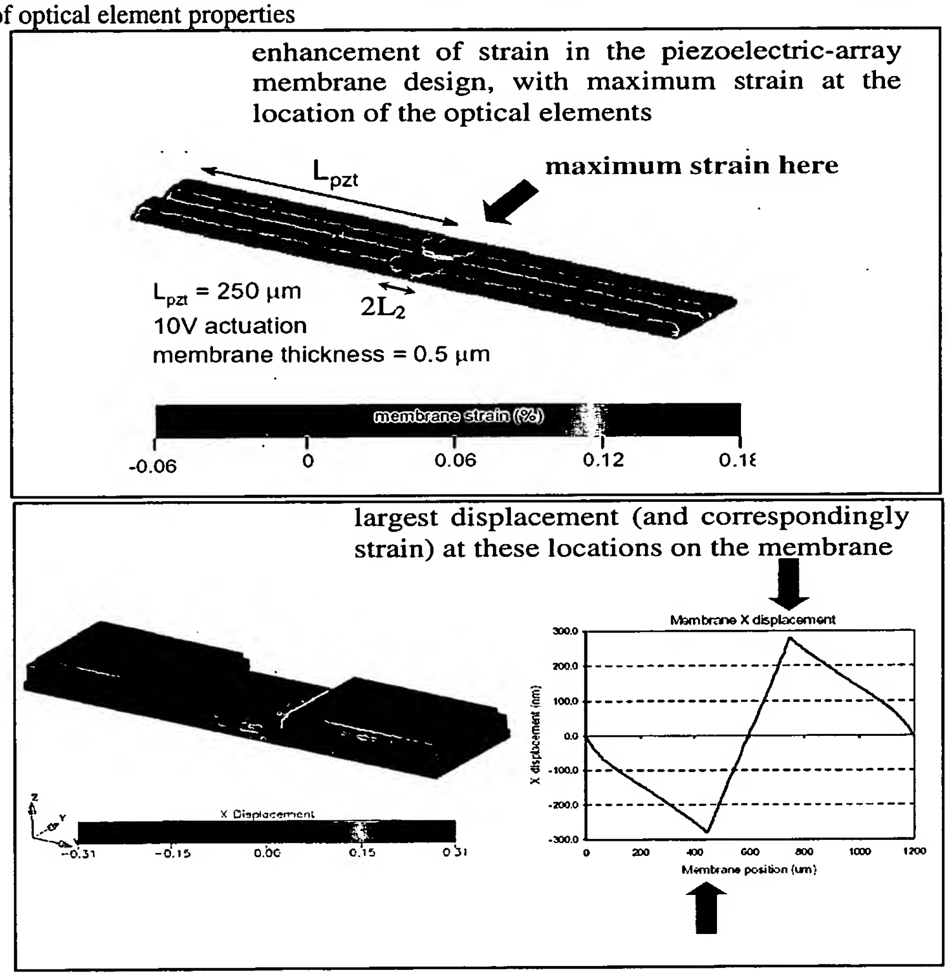

Notice that this *cannot be done* in Matsuura et al. '843, and hence is not discussed at all in the reference. This is because the piezoelectric has to be bonded directly to the substrate in their design, and hence no membrane deflection modes. Importantly, the inventive membrane design has resonant frequencies (say 1 – 100 kHz) that CAN BE REACHED with sinusoidal electrical excitation of the piezoelectric thin-film actuators arrays (which can also go up to 1 MHz, for example). On resonance, the displacement and strain (and hence tunability to the optical elements) is much larger, as described earlier and shown in the above plot.

2. **INTRINSIC ENHANCEMENT OF STRAIN** from any actuators to the optical elements through the membrane. The attachment of the plurality of piezoelectric actuators on the membrane, and the subsequent attachment of the optical elements to the membrane permits an

intrinsic amplification of the strain from the piezoelectric (or any other: magnetostrictive, electrostrictive, thermal, etc) actuator to the optical element.

This is shown in the below Figure. The enhancement factor is expressed as $L_{pzt}/L_1$, the ratio of the lengths in the membrane. The resulting strain at the location of the optical elements IS larger than the original strain from any of the actuators.

Figure caption: Intrinsic enhancement of strain through the piezoelectric-array membrane design, for increased tunability of optical element properties




Please note that there is NO enhancement of strain of any kind in the simple directly bonded piezoelectric substrate of Matsuura et al. '843. Hence in their design, the maximum strain is directly limited to only the strain that can be produced for any of the actuators.

3. **MULTIPLE EXCITATIONAL MODES** of the piezoelectric-array-membrane design for the optical elements. In one example, with four piezoelectric microactuators, for example, diagonal shear stress can be applied to the optical elements. This CANNOT BE DONE with the simple directly-bonded piezoelectric actuator of Matsuura et al. '843.

In another example, the plurality of piezoelectric arrays, in combination with the deformable membrane which is then attached to the optical elements, permits higher-order modal excitations, such as symmetric, anti-symmetric, 2nd order, 3rd order mode, which cannot be seen with Matsuura et al. This permits, for example, *compressive* strain on one optical element on the membrane, while *tensile* strain on another optical element on the membrane (but at a different location on the membrane) *simultaneously*. Even larger arrays of piezoelectric microactuators – together with deformable membrane – permits even more elements to be simultaneously tuned as required for the multiple optical functionalities on the silicon-based photonic chip. Therefore, Matsuura et al. '843 does not anticipate claims 1 and 11.

As to claims 5-7, 10, 15-17, and 20, they are dependent on claims 1 and 11, respectively. Therefore, claims 5-7, 10, 15-17, and 20 are also allowable for the same reasons argued with respect to claims 1 and 11.

Claims 2 and 12 are rejected under 35 USC §103 as being unpatentable over Matsuura et al. '843 in view of Caracci et al., US 6,445,838.

Caracci et al. '838 describes a Fabry-Perot resonator structure that includes an optical component comprising a substrate having a variable length for supporting and tuning the Fabry-Perot resonator by varying the variable length of the substrate in response to a variable stimulus.

Given that claims 2 and 12, are dependent on claims 1 and 11, the reasons argued for claims 1 and 11 are also applicable here. Also, Caracci et al. '838 does not address the deficiencies of Matsuura et al. '843. Therefore, the proposed combination of Matsuura et al. '843 and Caracci et al. '838 does not render obvious claims 2 and 12.

Claims 3, 4, 8, 9, 13, 14, 18 and 19 are rejected under 35 USC §103 as being unpatentable over Matsuura et al. '843.

Given that claims 3, 4, 8, 9, 13, 14, 18 and 19 are dependent on claims 1 and 11, the reasons argued for claims 1 and 11 are also applicable here. Also, the additional limitations of claims 3, 4, 8, 9, 13, 14, 18 and 19 further limit the inventive concept not taught by Matsuura et al. Therefore, Matsuura et al. '843 does not render obvious claims 3, 4, 8, 9, 13, 14, 18 and 19.

In view of the above amendments and for all the reasons set forth above, the Examiner is respectfully requested to reconsider and withdraw the rejections made under 35 U.S.C. §§ 102 and 103 and 112, second paragraph. Accordingly, an early indication of allowability is earnestly solicited.

If the Examiner has any questions regarding matters pending in this application, please feel free to contact the undersigned below.

Respectfully submitted,

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